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RESEARCH PAPER

Ground water aquifer properties of Sargodha City, Punjab, Pakistan

Muhammad Mobeen[1], Amatul Moin[*1], Mirza Naseer[2]

[1]Department of Earth Sciences, University of Sargodha, Pakistan

[2]Department of Earth Sciences, Nusrat Jahaan College, Chenab Nager, Pakista

Abstract

Groundwater is the major source for drinking and household use in the study area. Water quality deterioration has been reported as one of the most serious problem in Sargodha City, Punjab, Pakistan. The city is under severe water stress because of rapid decline in water quantity and quality. The present study examines the groundwater quality parameters of different aquifers categorized on the basis of their borehole depth. The aquifers mapping in the study area have not yet been made so for. The present study is a pioneer work of its kind as water quality of different aquifers from varied depth has been spatially analyzed. Random proportionate sampling was made for sample selection from one hundred different sites. The samples were analyzed by the authors in water quality testing lab. The site selection for sampling was based upon land-use classification of the study area. Seventeen parameters from each sample were calculated. The result of water samples was grouped according to the water table depth of each borehole. The four groups of aquifers showed a clear variation among different parameters i.e. Chloride, Sulfate, and TDS were found above the normal limit. The average electrical conductivity is 3625.4gm/l in group A is 335.28mg/l in B and 2868.636 in C. The average value of chloride in group A is 1368 mg/l while 1247.786 mg/l in group B and 1295.807 mg/l in C. The TDS values are 4270.04 mg/l in A and 2987.019 mg/l in B and 3409.091 in C. The all parameters showed a clearly deteriorating trend in groundwater quality of the study area. The findings of the study are in line with the different researches conducted in the surrounding areas. The results of the study are a wakeup call for the residents and district administration. The results have highlighted the water quality issue and asked for serious attentions from the relevant authorities.

*****Corresponding Author:** Amatul Moin ✉ mobeenuos@gmail.com

Introduction

The core objective of the previous study held in Pakistan is to increase sustainable access to safe drinking water in ruler areas. Pakistan Counsel of Research in Water Resource played important role by highlighting unsafe water issues in Pakistan. The report is consolidated effort of PCRWR which provide detailed information of water quality in rural and urban areas. Groundwater is the largest source of fresh water on planet earth. Groundwater is that part of the water which falls on earth surface socks into rocks and return back to ocean. Twenty percent of fresh water is consist on groundwater on earth. Groundwater move with extreme slowness through the fine chinks and pores of bed rock and regolith. An aquifer easily supplies the water to the well, installed in the formation Groundwater of Sargodha was contaminated with having high value of turbidity. Previous studies consist shows 88 percent sample were found unsafe (Tahir *et al.*, 2010). Groundwater is mined using various techniques like dug wells and bore wells. However man uses groundwater generally from up to a depth of only half a mile or even less water found at greater depths is not useable because its extraction is uneconomical. After percolation and runoff groundwater accumulation depend on permeability of rocks. Parameterization is use to understand regional groundwater trends objectively. Like aquifer depth, quantity, PH value, turbidity salinity excreta. The parameters commonly concern the geometry and distance in domain to be modeled and those physical properties of the aquifer that are more or less constraint with time but that may be variable in space. Most important parameters are topography, hydraulic conductivity, aquifer transmissivity, resistance, aquifer porosity, storage coefficient, capillarity.

Materials and methods

Sampling for the ground water analysis of Sargodha city was conducted in five visits from the months of March to May. Total number of samples are 101.Exploratory research is defined as the initial research into a hypothetical idea.
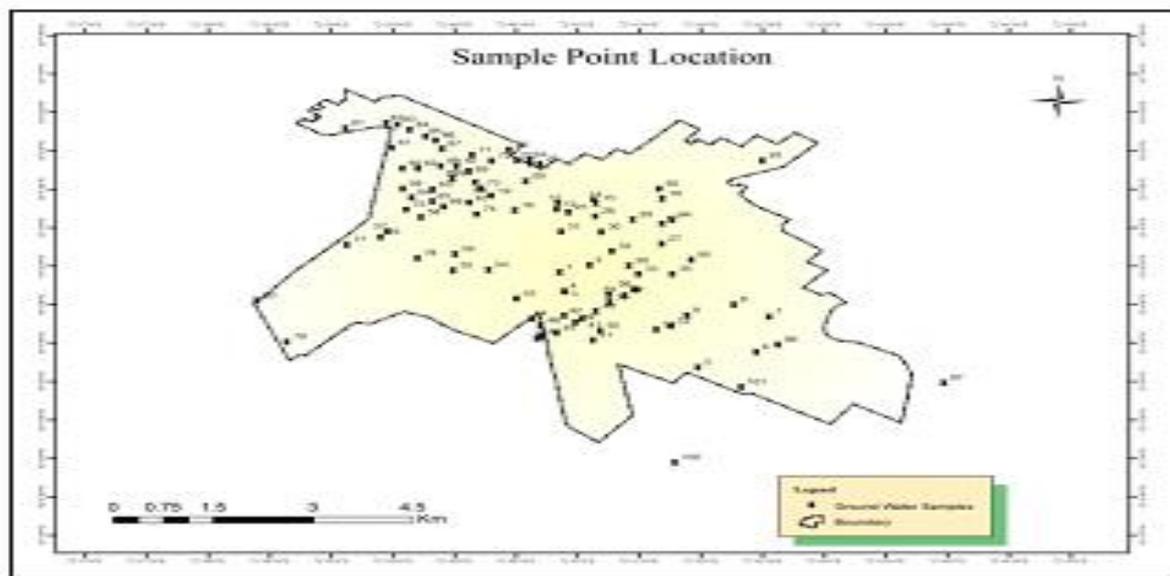

Fig. 1. Location of samples.

This is where a researcher has an idea or has observed something and seeks to understand more about it. It is an attempt to lay the ground work that will lead to future studies or to determine if what is being observed might be explained by a currently existing theory. Most often exploratory research lays the initial ground for future research".

While the analytical research deals with "data provided by laboratories to help and improve

understanding of resources and materials. Diverse technique and method development support research and provide data to other land management agencies and the public" (USGS.gov).

Water quality analysis deals with physio-chemical and biological parameter analysis. Or analysis of any other element concentration in water that is important for human and other biotic life or creating impact on them. Water quality analysis is important for all water usage purposes. Water is key to life so information regarding water quality is necessary for water supply, public health, agricultural and industrial purposes.
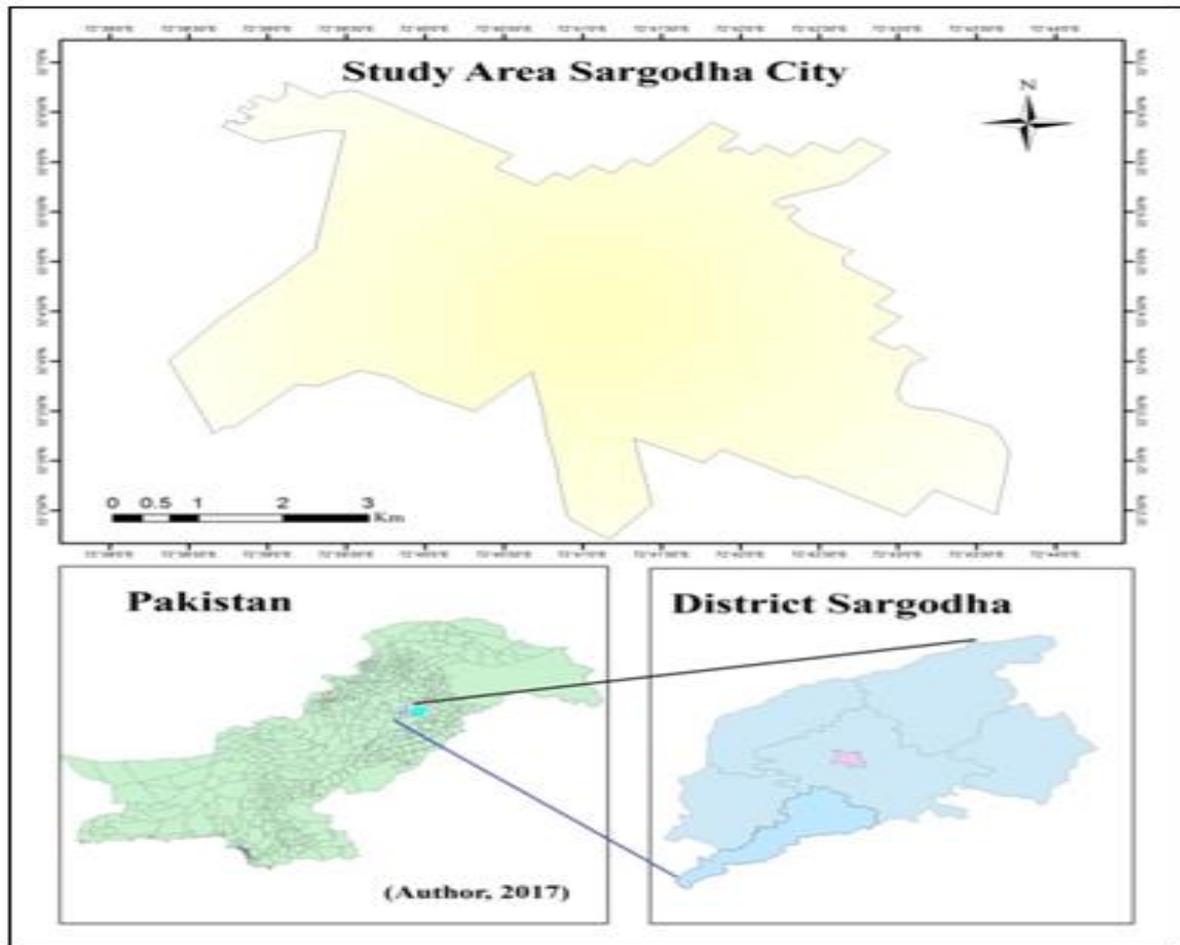

Fig. 2. Location Map.

Study area

The study area Sargodha city located in Punjab Pakistan. The Rank of Sargodha city is 11th largest city with fastest upbringing of Pakistan. Sargodha is emerged in 1903 British era. And use for Royal Air force. The city consist on total area of 5,854 Km2. And the total number of population is 1,500,000 with the density of 3.49(1998 censes). Longitudinal extend of Sargodha city is 72-38 degrees to 72-43 and latitudinal extend is 32-3 degree to 32-7 degrees. City is well linked with major hubs of country.

It is flat fertile land for agriculture and mainly ideal for citrus fruit. Climatically Sargodha come in Bsh of Koppens Classification of Climatic regions were "B" is stand for arid small "s" is stands for Dry summer and "h" is stands for Hot. Sargodha city had evidences of experiencing climate change on its rainfall temperature and humidity. Physiography of Sargodha is flatten with fertile cultivating land between two rivers Jhelum in west and Chenab in East of Sargodha. Sargodha also small hills on Faisalabad road. These hills called Kerana hills.
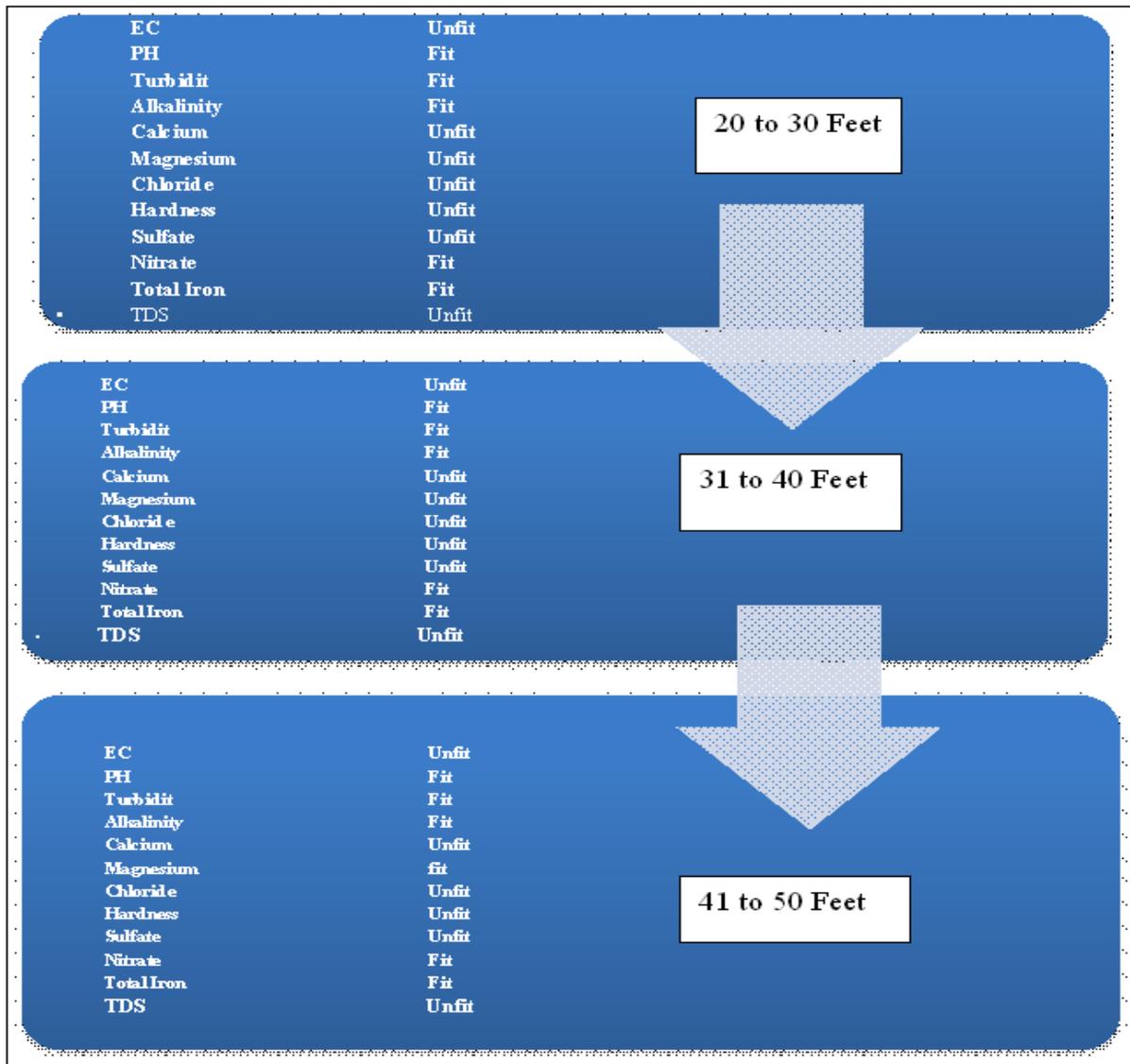
EC	Unfit
PH	Fit
Turbidit	Fit
Alkalinity	Fit
Calcium	Unfit
Magnesium	Unfit
Chloride	Unfit
Hardness	Unfit
Sulfate	Unfit
Nitrate	Fit
Total Iron	Fit
TDS	Unfit

20 to 30 Feet

EC	Unfit
PH	Fit
Turbidit	Fit
Alkalinity	Fit
Calcium	Unfit
Magnesium	Unfit
Chloride	Unfit
Hardness	Unfit
Sulfate	Unfit
Nitrate	Fit
Total Iron	Fit
TDS	Unfit

31 to 40 Feet

EC	Unfit
PH	Fit
Turbidit	Fit
Alkalinity	Fit
Calcium	Unfit
Magnesium	fit
Chloride	Unfit
Hardness	Unfit
Sulfate	Unfit
Nitrate	Fit
Total Iron	Fit
TDS	Unfit

41 to 50 Feet

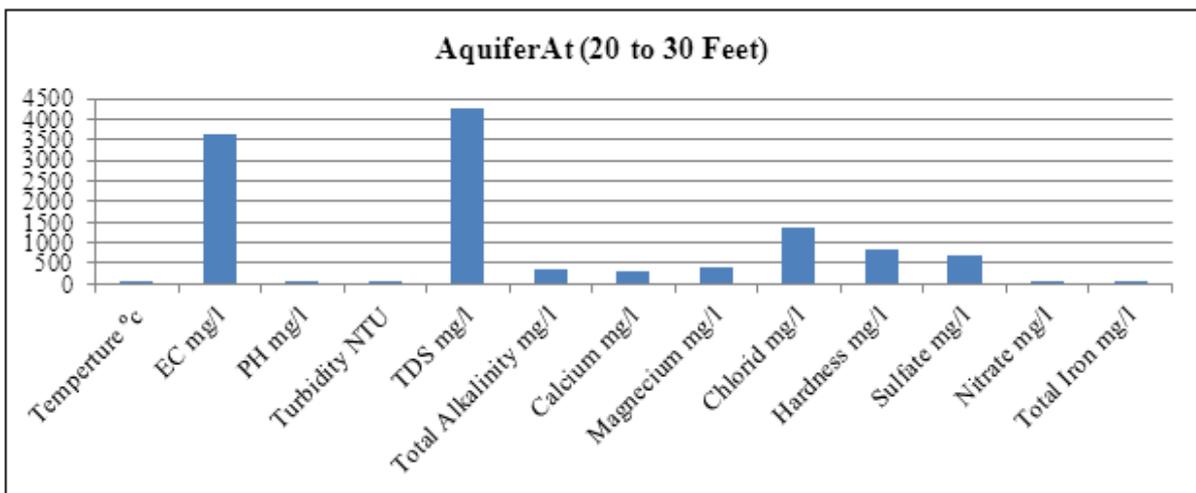**Fig. 3.** Quality of water of Aquifer at different depth.

Fig. 4. Ground water Aquifer layer at Group A.

Results and discussion

Layers of Aquifer

Aquifer layers are divided into three different groups. Group A is consist of twenty two samples and the borehole depth of this group is 20 to 30 feet. The second group is B having 53 samples and it is the largest group of this study and the borehole depth of this group is 31 to 40 feet. The last group is group C having twenty five samples and the depth of samples in this group is 41 to 50 feet. There is only one sample is found on depth of seventy feet.
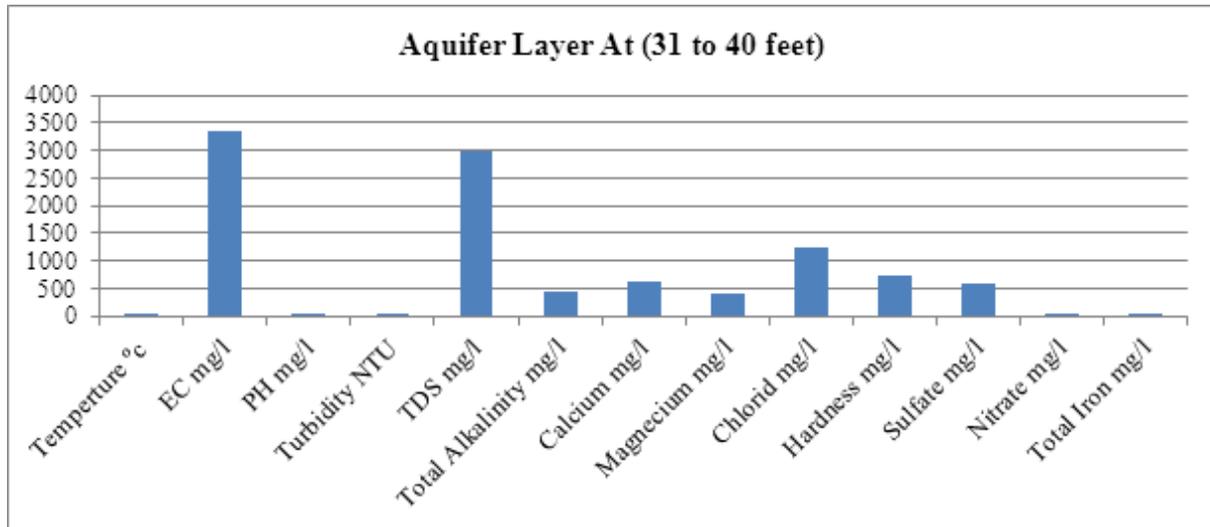
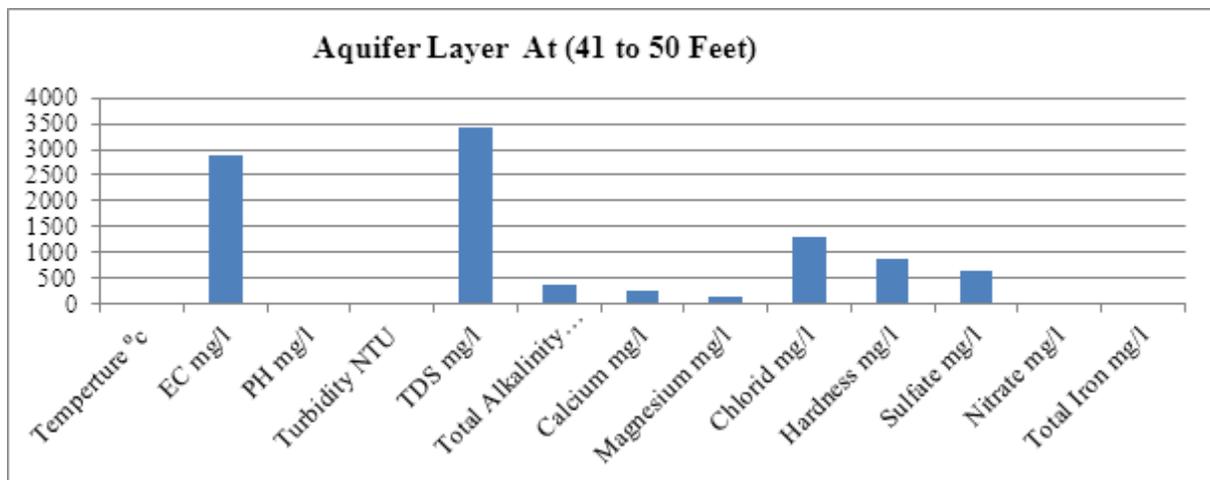**Fig. 5.** Ground water Aquifer layer at Group B.

Fig. 6. Ground water Aquifer layer at group C.

Properties of Aquifers:

There are both physical and chemical properties of water samples were calibrated.

These properties were Taste, Odor, Color, and Turbidity which are physical in nature while, PH, Magnesium, Calcium, TDS, Total Alkalinity, EC, Chloride, Nitrate, Sulfate, Hardness and Iron are chemical in nature.

Aquifer Layers at Deferent Depths

The chart is showing fitness levels of water table aquifer layers of Sargodha city. At first layer five parameters are fit out of 11. Same as with the second layer while when we move towards three layer six parameters are fit out of 11. The flow chart is showing only those parameters which are tested in water quality testing laboratory.
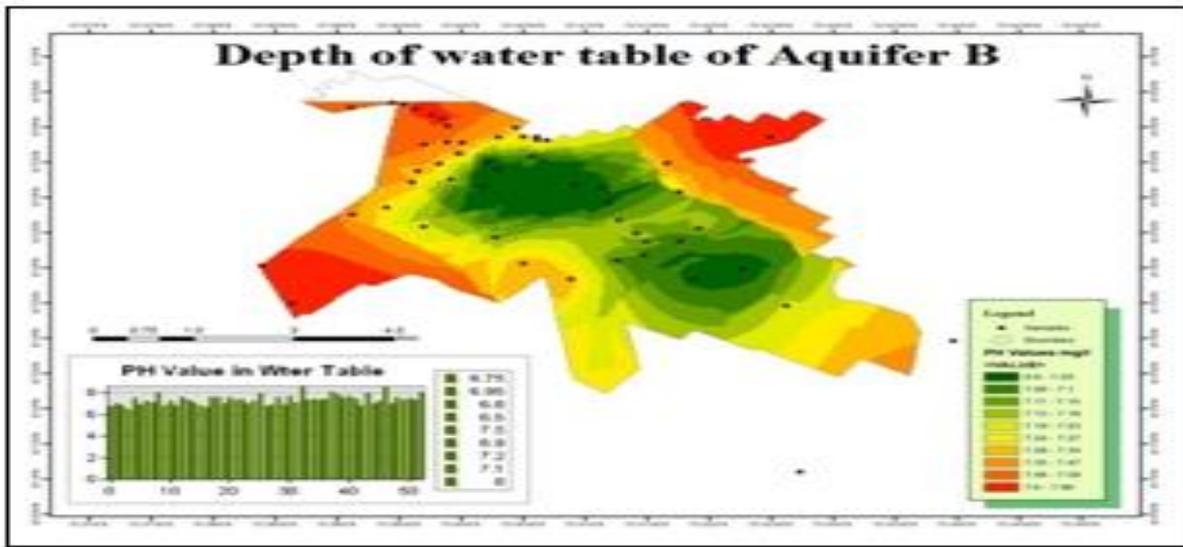
Fig. 7. Depth of water table of Aquifer B
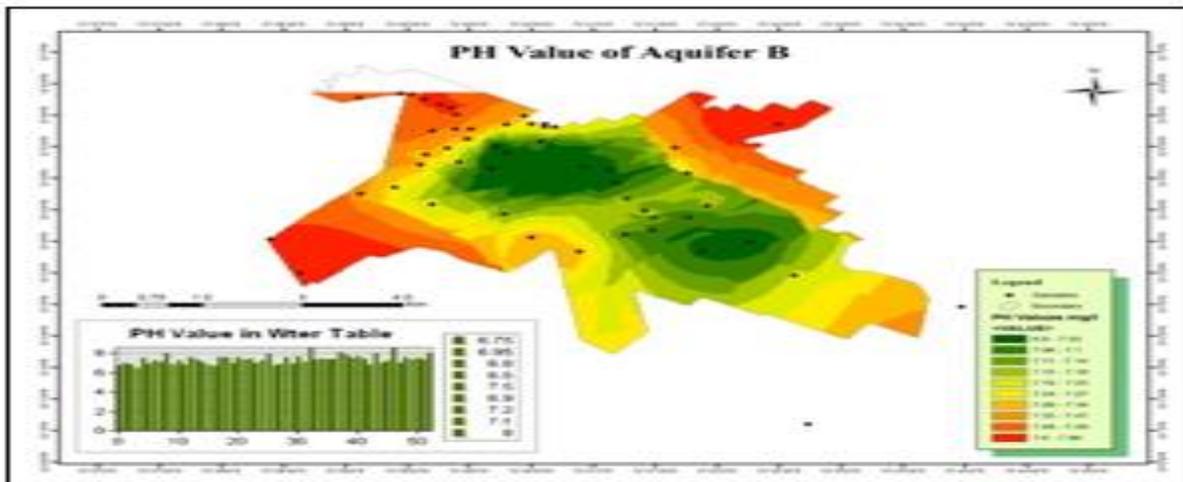

Fig. 8. pH value of Aquifer B

Above graph is showing the average values of physical and chemical and parameters of ground water of Sargodha city at the aquifer layer of 20 to 30 feet depth. The temperature of water at this depth is 30.73 degree Celsius. The average value of electrical conductivity at this depth is 3625.4mg/l. PH of value at this depth is 7.26 mg/l. Average turbidity at this depth is 0.98NTU.

Total alkalinity value is 371.56 mg/l. As well as the chemical parameter of water also shown in above graph. Average concentration of calcium at this depth is 320.466 mg/l. Average accumulation of magnesium at this depth is 420.42 mg/l.

Chloride value at this depth is 1368 which is seems very high in chloride scale of WHO. The total hardness is 857.32 mg/l. sulfate concentration is also very high at this depth of aquifer which is 713.374 mg/l. Nitrate and total iron concentration. Average Nitrate value is 0.004356 mg/l. and the total iron value is 0.02013. This is the overall picture of ground water parameter at the depth of 20 to 30 feet aquifer layer.

The above graph is showing the average values of Physical and chemical parameters of ground water aquifers of Sargodha city at depth of 31 to 40 feet.
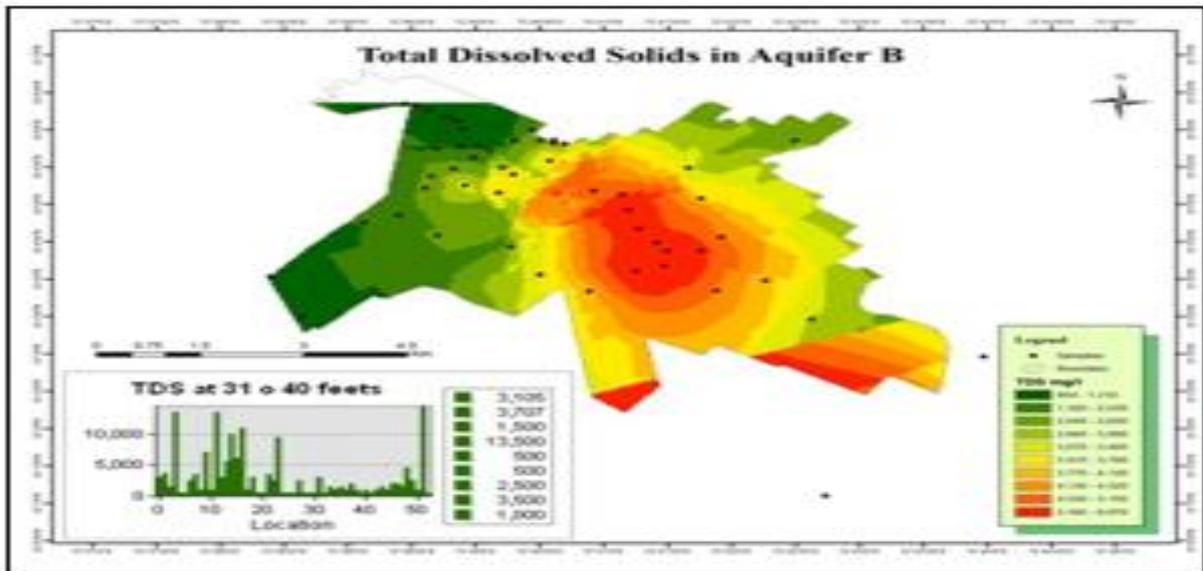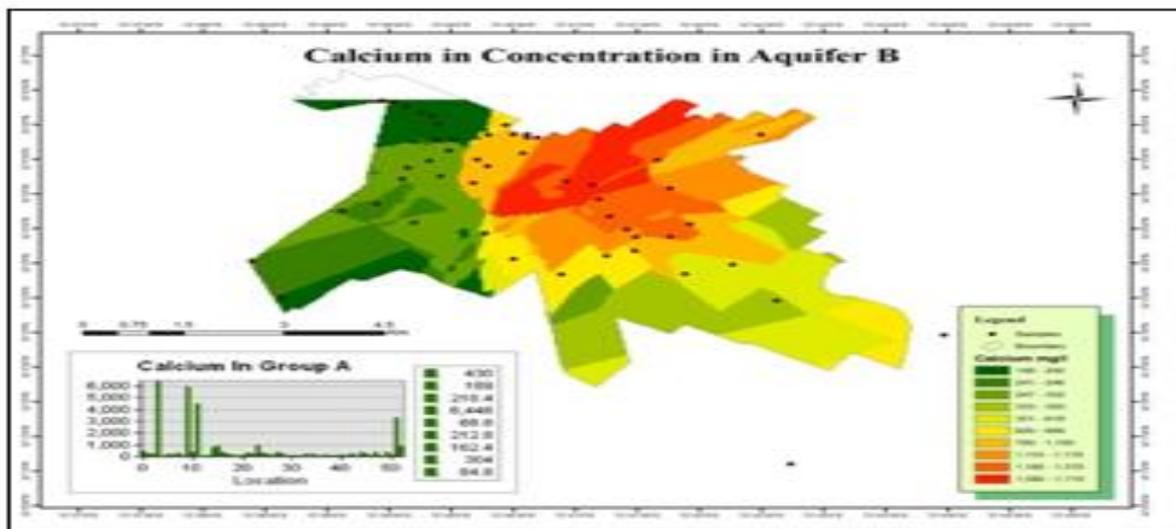
Fig. 9. Total dissolved solids in Aquifer B

Fig. 10. Calcium concentration in Aquifer B

The average temperature of water at this depth is 33.71 degree Celsius. The average electrical conductivity is 3355.28 mg/l. The average PH at this layer of aquifers is 7.32 which is fit on WHO PH scale. The average value of turbidity at depth of 31 to 40 feet is 0.96 NTU. The average value of total dissolve solids is 2987.019 mg/l. the average total alkalinity is 449.1132 mg/l which falls under WHO standards of alkalinity scale for drinking water. Calcium average value stands at 610 mg/l which is very high at WHO scale of calcium. Magnesium of ground water of Sargodha city at this depth is 396.5642 mg/l. chloride

value is 1247.786 mg/l. total hardness falls at 729.7653 mg/l. sulfate average is 597.5468 mg/l. Nitrate and total iron stands under the limit of WHO standards of nitrate and iron. Average value of nitrate is 0.01084 mg/l and total iron stands at the average of 0.010779 mg/l.

The above graph is showing the average condition of physical and chemical layer of aquifers at the depth of 41 to 50 feet below earth surface.

At this aquifer layer of Sargodha city average temperature is 34.36 degree Celsius.
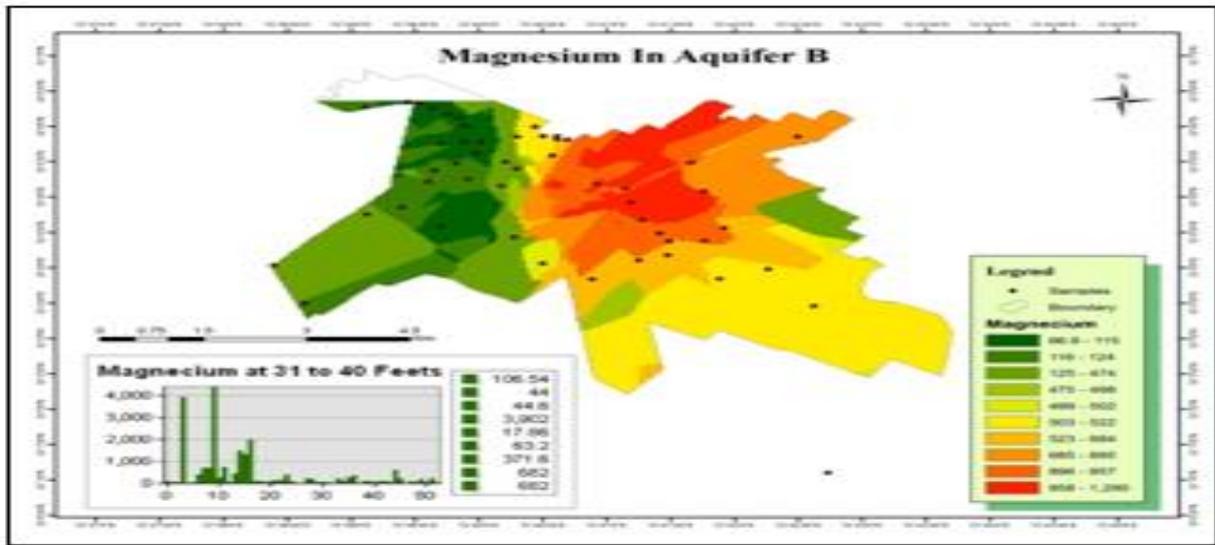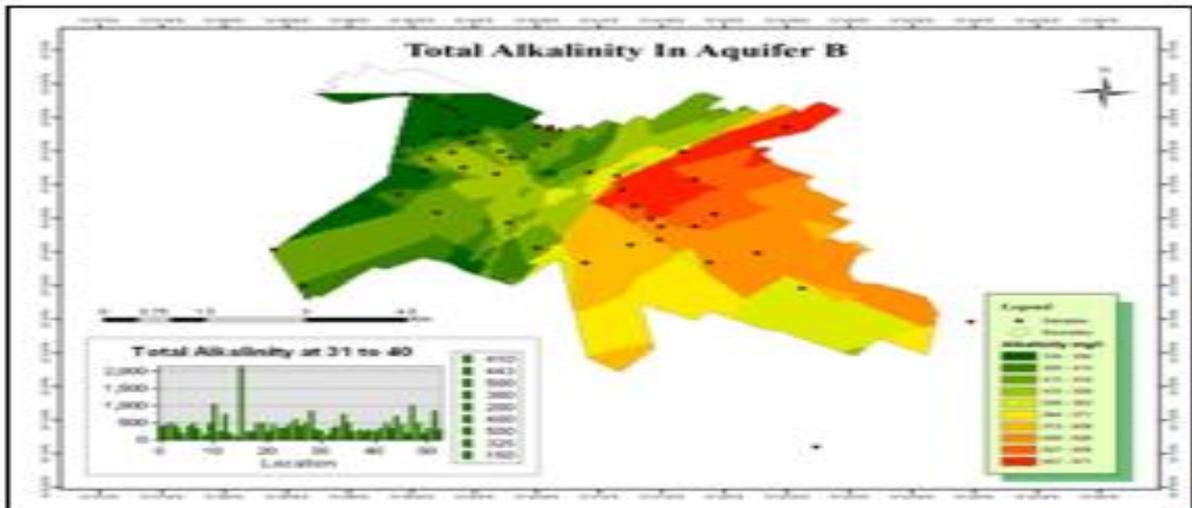
Fig. 11. Magnesium in Aquifer B

Fig. 12. Total Alkanity in Aquifer B

The average value of electrical conductivity falls at 2868.636 mg/l. PH value is 7.27 mg/l. water is 0.39 NTU turbid. TDS value is 3409.091 mg/l. total alkalinity is 359.7727 mg/l. calcium is also higher than its permissible limit the average value of calcium is 264.0182 mg/l. magnesium's average value at this layer is under the permissible limit of magnesium.

The value of sample here is 150.2295 mg/l. chloride value is 1295.807 mg/l. water hardness is 864.9545 mg/l. sulfate average concentration is 644.635 mg/l. nitrate average value is 0.0055 mg/l and total iron is 0.007145 mg/l. The values of nitrate and sulfate also fit at WHO scale for them.

Depth of water table of Aquifer A

Now the water table depth in group A is showing in the above map which is between 31 to 40 feet. The map is showing variations in all around the study area.

The north western part of the study area is found having borehole depth 36 feet to 38 feet. While borehole depth in the central part of city the city is 33 to 35 feet. And the eastern part hand pumps are installed at the depth of 30 to 32 feet.
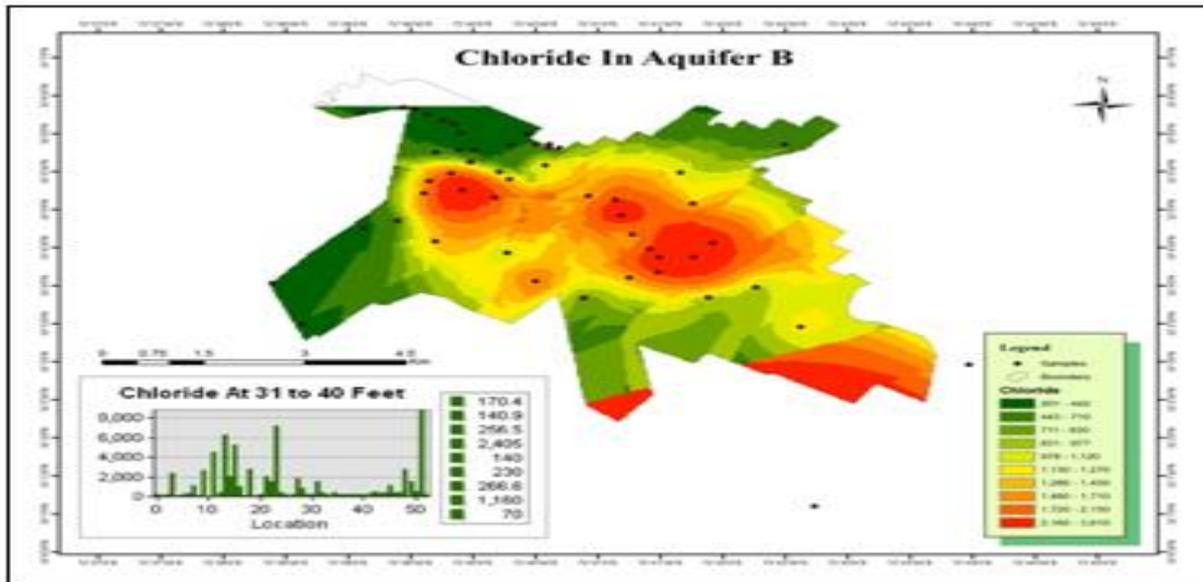
Fig. 13. Chloride in Aquifer B

PH Value of Aquifer B

This map is showing PH value condition in water table aquifer layer in group which falls in 6.1 to 7.9 mg/l. which is under the limit of WHO standards for PH. The values are found within the limit of WHO standard for PH in drinking water.

Total Dissolved Solids in Aquifer B

Total dissolve solids at the depth of 31 to 40 feet aquifer layer of water table are found very high at TDS scale of WHO. The central part of the city is having very high values of total dissolved solids. While the northern less built up area is found comparatively low. But the average of TDS at this depth is above the permissible limit of WHO.
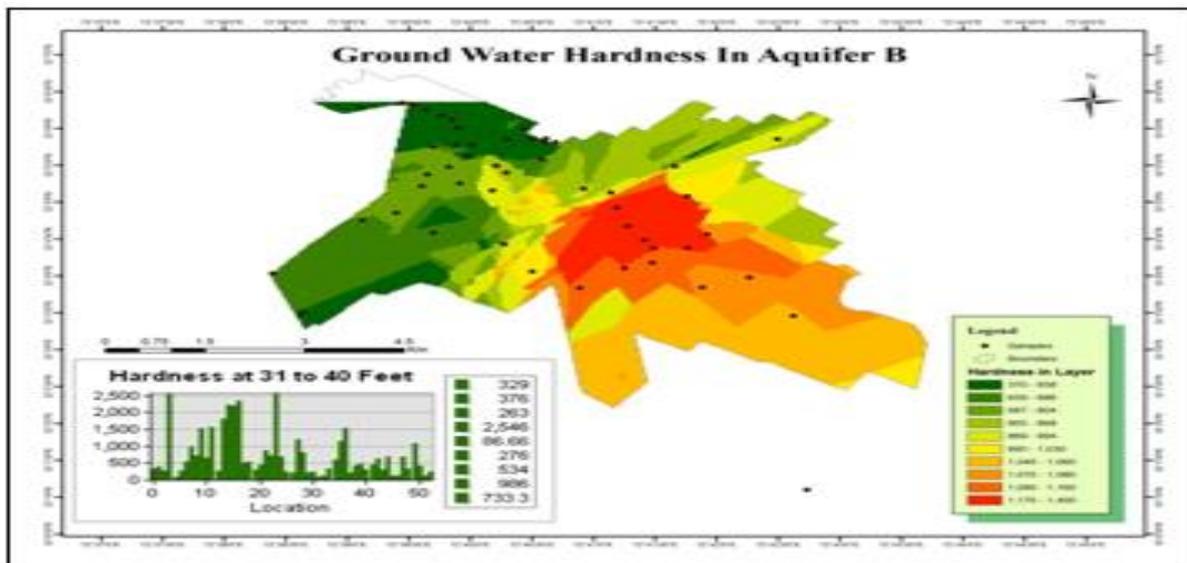

Fig. 14. Ground water Hardness in Aquifer B

Calcium in Concentration in Aquifer B

The condition of calcium at the depth of 31 to 40 feet layer of aquifers in water table showed in above map.

The calcium concenteration at this depth is very high at the scal of calcium given by WHO. The northern part of the city contains minimum values as

compared to the central part the value of calcium is high an alarming level at this depth and the average is also above the permissible limit of WHO.

Magnesium in Aquifer B
Magnesium concentration in water table aquifer layer at the depth of 31 to 40 feet is unfit.

The above figure is showing the spatial patterns of value distribution in study area. Western and north part of the city contains less concentration of magnesium as compared to central and eastern part. But the average value of magnesium is found unfit on WHO standards of drinking water.
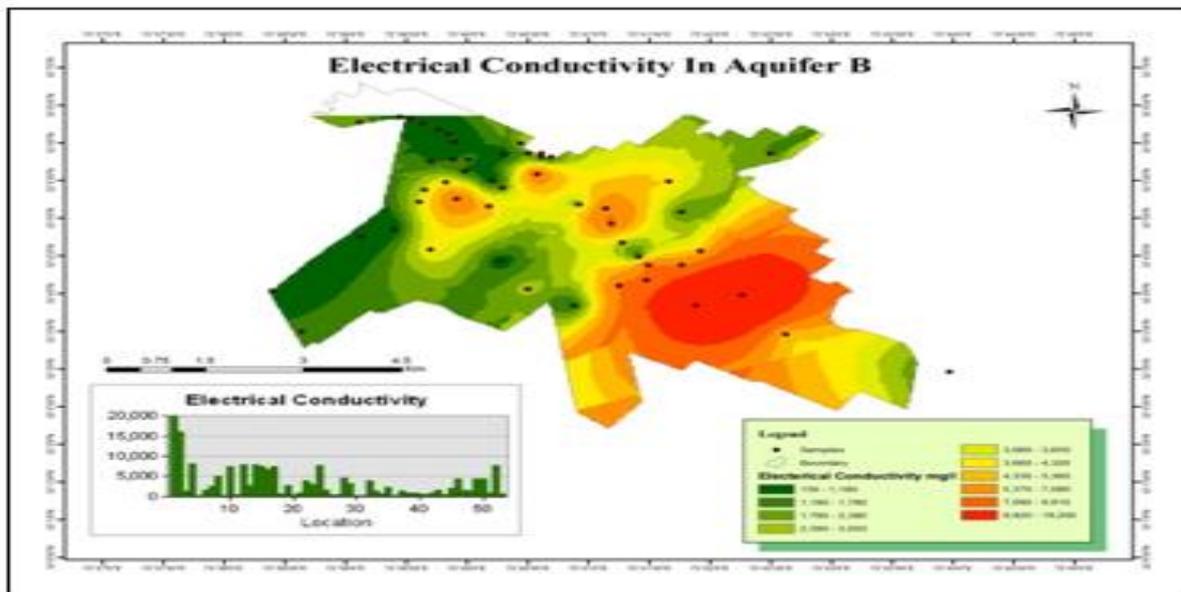

Fig. 15. Electrical conductivity in Aquifer B

Total Alkalinity in Aquifer B
The value of Alkalinity in water table aquifer is found unfit at this layer. The spatial pattern is showed in the above figure. The highest values are found in eastern and Sothern part of the study area. While the west part is contains lower values but still the values are not under limit of WHO standard for drinking water.

Chloride in Aquifer B
Water table aquifer layers at this depth contains high concentration of chloride. The central part of the city, named as urban area Satellite town and PAF area found with very high values of chloride. And the average value is also above the WHO limit of chloride for drinking water. Total Hardness of Water Table Aquifers Layer

Ground Water HardnessIn Aquifer B
The water table aquifer layers at this depth are found unfit. The water of Sargodha is very hard at the hardness scale of water for drinking.

The map is showing the spatial variations and fluctuation of ground water hardness in the layer of aquifers at this depth. The central build up area is found having very hard water followed by Sothern part of the city. While the western and northern parts are showed lower values as compared to the other part of the city. The reason is may be the less building structure in this part of the city. But still the vales are above the permissible limit of WHO. And the average is also found above this limit.

Electrical conductivity in Aquifer B
The electrical conductivity of water table aquifer layer at depth of 31 to 40 feet found very high at WHO scale for electrical conductivity. The figure is showing spatial patterns of Electrical conductivity in the study area at this depth of aquifer layer. The highest concentration of electrical conductivity found in Sothern and eastern part of the city central portion also having high values of Electrical conductivity.

While when we move towards the northern and western part of the city values of electrical conductivity are lower as compared to the other part of the city.

Conclusion

The present condition of ground water aquifer layers of Sargodha city was found unsafe for drinking purpose. The average concentrations of chemical and physical characteristics were found high in different layers of aquifers. The most alarming concentration of physical and chemical parameters is in group B. Chloride concentration was found very high in all aquifer layers. The average concentration of chloride in group B is 1247.786 mg/l while the average concentration of calcium is also high with 610.517 mg/l. The average concentration of sulfate is 597.546 mg/l. Alkalinity found with the average concentration of 449.1132 mg/l while the physical parameters are also found in abundance in all aquifer layers. The average hardness is 729.76 mg/l in group B. The average electrical conductivity is 3355.28 mg/l. The average PH is found safe in all depths of aquifer layers. Nitrate, iron and Turbidity are also found safe with averages of 0.010mg/l and average of Turbidity in group B is 0.01 NTU.

The overall appraisal for water samples of all aquifers is unsafe for drinking and some of the samples even unsafe for household use.

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